Nevada's Nutrient Criteria Strategy

July 2007

YSI Dissolved Oxygen Monitoring Sonde on the Carson River below Highway 395 (Cradlebaugh Bridge), Photograph by Z. Latham, June 2004

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Introduction

Significant efforts are underway throughout the country to develop more appropriate nutrient criteria. Since 1998, Nevada has been participating in our Region IX RTAG (Regional Technical Advisory Group) efforts toward improved nutrient standards. While the focus of the RTAG efforts have largely been on California waters, NDEP has participated in the process in hopes of identifying an approach for improving Nevada's existing nutrient criteria. It was also thought that Nevada could potentially follow California's nutrient criteria development plan. However some of Nevada's unique needs have made it necessary to present its own criteria strategy, building off of the Region IX RTAG efforts and those of other states.

While Nevada has nutrient standards for most of the waters listed in the regulations, there are a number of problems with these criteria. Most significantly, the beneficial criteria focus on phosphorus (and not nitrogen) for eutrophication control. Another emerging challenge is the establishment of nutrient criteria for waters being added to the regulations in the future. There is a need for a consistent, scientifically defensible approach for assigning nutrient criteria to these waters. The objective of this document is to begin defining NDEP's strategy for: 1) dealing with our existing nutrient criteria., and 2) addressing future nutrient criteria needs. This document needs to be considered a living, changing document. It is expected that as more information is gathered and more experience is gained, strategy changes may be appropriate.

Background on Nutrients and Impairment

Exceedances of total phosphorus standards are common in many of Nevada's streams. However in many cases, it is not known if the phosphorus levels are actually impacting the beneficial uses, e.g. aquatic life, recreation, etc. As discussed by TetraTech (2005), the use of nutrient concentrations alone are poor predictors of assessing eutrophication impacts. Also, Dodds et al. (2002) examined data from over 600 streams and found that nutrients concentrations accounted for less than half of the variance in the benthic algae biomass. They speculated that other factors, such as flow, light availability, channel conditions, grazing, were responsible for the remaining variability. In a detailed study of Colorado streams, Lewis, Jr. and McCutchan, Jr. (2005) found even less of a relationship between nutrient concentrations and benthic biomass, with DIN (dissolved inorganic nitrogen) accounting for only 15% of the variance. No statistically significant relationship was found between benthic biomass and other nitrogen and phosphorus species.

Given the problems of relying on nutrients concentrations to predict impairment, perhaps a more direct initial indicator of whether or not a stream is nutrient impaired is with estimates (qualitative or quantitative) of algal biomass. While some algae is a necessary component of the ecosystem, excessive algae can impact the beneficial uses in a variety of ways. According to EPA (2000):

> *"Algae are either the direct or indirect cause of most problems related to excessive nutrient enrichment, e.g. algae are directly responsible for excessive, unsightly periphyton mats or surface plankton scums, and may cause high turbidity, and algae are indirectly responsible for diurnal changes in DO and pH"*

Due to its importance as an impairment indicator, algae monitoring is an important component of any nutrient investigation. However, it is important to recognize that algal biomass levels can be highly variable with time and space and that some understanding of algal dynamics is necessary before designing the appropriate protocols. Following is a brief description of the main factors affecting benthic algae biomass levels. Any one or more could be the limiting factor(s) at a given place and at a given time:

Nutrient concentrations: Nitrogen and phosphorus are the main nutrients that cause excessive algal growth (EPA, 2000) and nutrient concentrations can affect algae growth rates. However, there can be a time lag between nutrient enrichment and algal response (EPA, 2000). It is interesting to note that "*…Diatoms are usually the first to establish, with more time required for FGA [filamentous green algae] to colonize due to their more complex reproduction requirements*" (EPA, 2000).

Another confounding factor is the possible existence of a diel fluctuation in the nutrient concentrations in streams with algal activity. In his recent modeling of the Carson River (a nitrogen-limited system in Nevada), Latham (2005) simulated a diel fluctuation in nitrate levels from 0.0 in the middle of the day to around 0.1 mg/l (as N) in the night. Though no data have been collected to confirm this fluctuation, it should not be unexpected given the low nitrogen in this system and the fact that the algal photosynthesis activity (and its consumption of nutrients) is peaking during the day and shutting down at night. Nolan et al. (1995) sampled Little Lost Man Creek in Northern California approximately every 2-hours for a 2-day period and found nitrate levels fluctuating from about 0.028 mg/l in the afternoon to 0.042 mg/l in the evening. Kent et al. (2005) monitored algal productivity and nitrogen levels in an effluent dominated concrete lined stream and found total nitrogen levels fluctuating from approximately 3 mg/l (as N) during the daylight hours up to approximately 8 mg/l (as N). Gregory (1979) found a greater than 80% decrease in nitrate levels from the midnight to mid-day concentrations for fifth order streams in Oregon. This information suggests that a grab sample in the middle of the day may not be indicative of levels available for algal growth, particularly in systems with low nitrogen or phosphorus and/or high algae activity.

Flow: Algal biomass varies with time with peak levels generally occurring during the summer when flows are low and temperatures high. Biomass levels can vary from year to year, with higher flows leading to lower temperatures and possibly less algae. Another consideration is the time since the system has experienced a scouring-flow event. Biggs (2000) found that 62 percent of the variance in peak biomass was explained by the time since the last flood event (Figure 1.) Similarly for Colorado streams, Lewis, Jr. and McCutchan, Jr. (2005) found a positive relationship between periphyton biomass and time elapsed since the beginning of the growing season.

Temperature: Increased water temperature are known to increase biological activity, including algae growth (Tetra Tech, 2002). However, cladophora algae has been found to die-off at temperatures exceeding 23.5 °C (Dodds and Gudder, 1992). These die-off events can lead to low dissolved oxygen levels as the algae decay. On the other end of the spectrum, lower temperatures can lead to lower algal biomass. Lewis, Jr. and McCutchan, Jr. (2005) identified an inverse relationship between periphyton biomass and elevation, therefore an positive relationship between biomass and temperature.

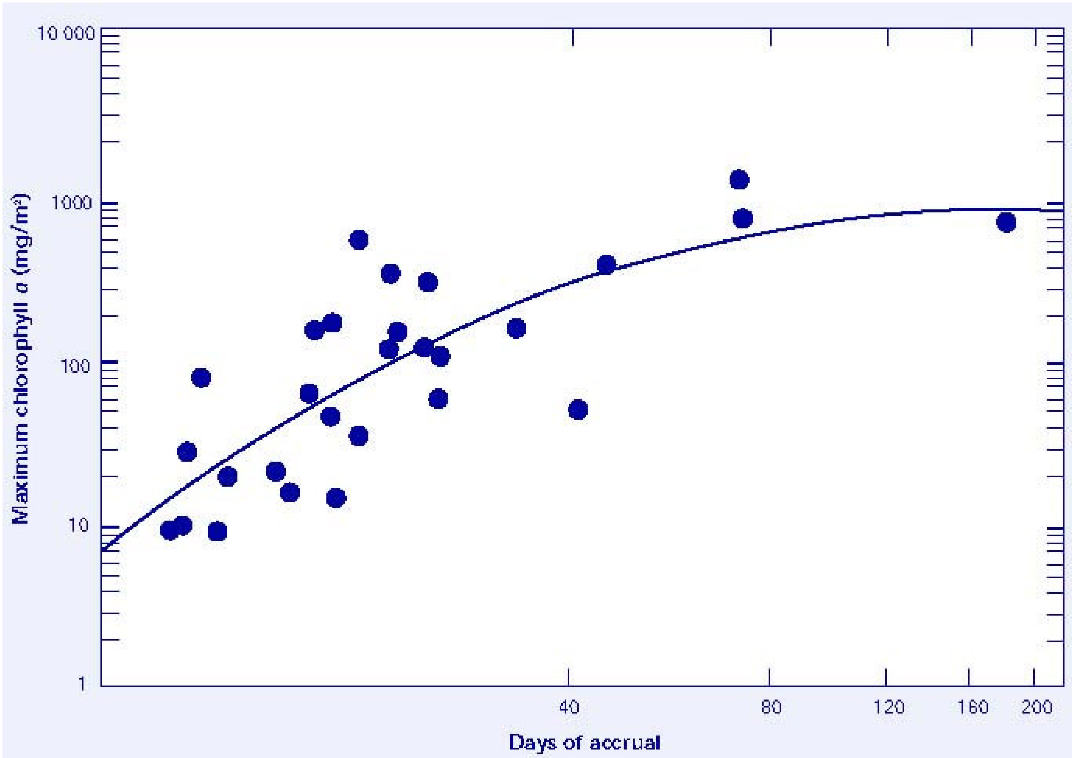

Figure 1. Maximum Chlorophyll a Concentrations as a Function of Mean Days Since Last Flood Event (from Biggs, 2000)

Shading/light: Welch and others (1992) have found that shading can substantially reduce algal production. Low turbidity levels (>10 NTU) can also inhibit periphyton growth (Quinn et al., 1992). Another shading source to consider is the topography of the surrounding landscape.

Substrate conditions: Large, rough substrates are the best habitat for periphyton due to its need to attach to objects. Sedimentation on top of rocky substrate can decrease periphyton biomass (Welch et al., 1992).

Biological community structure: Steinman (1996) has found that dense populations of algae consuming grazers can lead to negligible algal biomass, even with high nutrient levels. Also, there is some evidence that bacteria may outcompete algae for nutrients and secrete allelopathic substances that inhibit algal growth (EPA N-Steps Website, 2007).

Background on EPA Guidance

During the 1990s, reports on water quality conditions were indicating that nutrients were a leading cause of waterbody impairment throughout the country. At that time, many states did not have numeric nutrient criteria in their water quality standards. In 1998, President Clinton and Vice President Gore released their Clean Water Action Plan which called on EPA to increase nutrient criteria development efforts. Later that same year, EPA released the *National Strategy for the Development of Regional Nutrient Criteria* describing their approach in developing nutrient information and working with states and tribes in the adoption of nutrient criteria. Since the issuance of this strategy, EPA has produced some key documents in support of nutrient criteria development:

- *Nutrient Criteria Technical Guidance Manual: Rivers and Streams (2000); Nutrient Criteria Technical Guidance Manual: Lakes and Reservoirs* (2000)

  These documents "…*provide scientifically defensible technical guidance to assist States and Tribes in developing regionally-based numeric criteria and algal criteria*…"

- Four documents (covering Nevada and other areas) generally titled *Ambient Water Quality Criteria Recommendations – Information Supporting the Development of State and Tribal Nutrient Criteria*

  - Rivers and Streams in Nutrient Ecoregion II (Western Forested Mountains) (2000)
  - Lakes and Reservoirs in Nutrient Ecoregion II (Western Forested Mountains) (2000)
  - Rivers and Streams in Nutrient Ecoregion III (Xeric West) (2000)
  - Lakes and Reservoir in Nutrient Ecoregion III (Xeric West) (2000)

  These documents present EPA 304(a) nutrient criteria for Ecoregion II and III (portions of which are within Nevada). See Section **EPA 304(a) Criteria** section for more detail.

On January 9, 2001, EPA issued a memorandum recommending that states develop a nutrient criteria plan to describe their intended process for replacing narrative criteria with numeric criteria. However, EPA has always considered that Nevada already has numeric nutrient water quality standards and has not been looking to NDEP for such a document. While Nevada has nutrient standards for most of the waters listed in the regulations, the beneficial criteria focus on phosphorus (and not nitrogen) for eutrophication control.

As part of EPA's *National Strategy*, Regional Technical Assistance Groups (RTAG) (consisting of EPA staff, representatives from the states within the region, etc.) were formed throughout the U.S. to facilitate improved nutrient criteria development. Within EPA Region IX, EPA, Nevada, Arizona and California agency representatives have been participating in a series of RTAG meetings and publication reviews. Following considerable work, the RTAG recently released a final report presenting a nutrient criteria development approach for California. The RTAG findings are discussed in more detail in the **EPA Region IX RTAG Findings** section of this report

EPA 304(a) Criteria

In 2001, EPA published recommended water quality criteria for nutrients under Section 304(a) of the Clean Water Act, with the intention that they serve as a **starting point.** EPA strongly encourages states and tribe to refine these recommendations following key elements in the EPA Technical Guidance Manuals. States and tribes are encourage to address both chemical causal variables (nitrogen, phosphorus) and early indicator response variables (chlorophyll-a, turbidity) in the development of criteria or procedures for translating narrative criteria.

EPA recommends 3 options for developing nutrient criteria (in order of preference)

1. Develop criteria that fully reflect localized conditions and protect specific designated uses, using EPA's Technical Guidance Method. Such criteria may be expressed either as numeric criteria or as procedures to translate a state or tribal narrative criterion into a quantified endpoint

2. Adopt EPA's 304(a) Criteria Recommendations, either as numeric criteria or as procedures to translate narrative criterion into a quantified endpoint.
3. Develop a Unique System using – empirical approaches, loading models, cause and effect based studies/relationships, other analytical tools.

Rivers and Streams

In developing their 304(a) recommendations for rivers and streams, EPA first compiled datasets from Legacy STORET, NASQAN, NAWQA from 1990 to 1998. Using these data, EPA calculated assumed "reference" conditions for various parameters within each ecoregion (Level III). EPA's Technical Guidance Manual for Developing Nutrient Criteria for Rivers and Streams describes 2 ways to establish reference values:

1. Choose the 75th percentile of a population of reference streams. This is EPA's preferred way to establish reference conditions. The 75th percentile was selected since it is likely associated with minimally impacted conditions, and will be protective of designated uses.
2. When reference streams are not identified, use the 25th percentile of the entire population of data to represent a surrogate for an actual reference population. According to EPA, case studies have indicated that the 25th percentile from an entire population roughly approximates the 75th percentile of the reference population.

In the determination of the 304(a) criteria for our region, EPA did not have information on minimally impacted sites available on a national basis, so they relied on the 25th percentile of the entire dataset (within an ecoregion) for the establishing the criteria. One problem with this approach is that it automatically assumes that 75% of the streams are impaired for nutrients. **Another problem is that the STORET data do not include all of NDEP's data.** Table 1 summarizes the recommendations for the Nevada ecoregions. Figure 2 shows the location of the various Level III ecoregions in Nevada.

In lieu of using the 304(a) criteria, States and tribes are encouraged to determine their own reference sites, compile additional data and evaluate at finer geographic scales.

Table 1. Reference Conditions for Level III Ecoregion Rivers and Streams, mg/l (25th Percentile of Dataset)

Parameter	Ecoregion 5 (Sierra Nevada)	Ecoregion 13 (Central Basin and Range)	Ecoregion 14 (Mojave Basin and Range)	Ecoregion 80 (Northern Basin and Range)
TKN	0.10	0.228	0.288	0.23
NO2 + NO3	0.01	0.038	0.353	0.025
TN (calculated)	0.11	0.266	0.641	0.255
TN (reported)	0.29	0.425	0.67	0.483
TP	0.015	0.0288	0.010	0.055

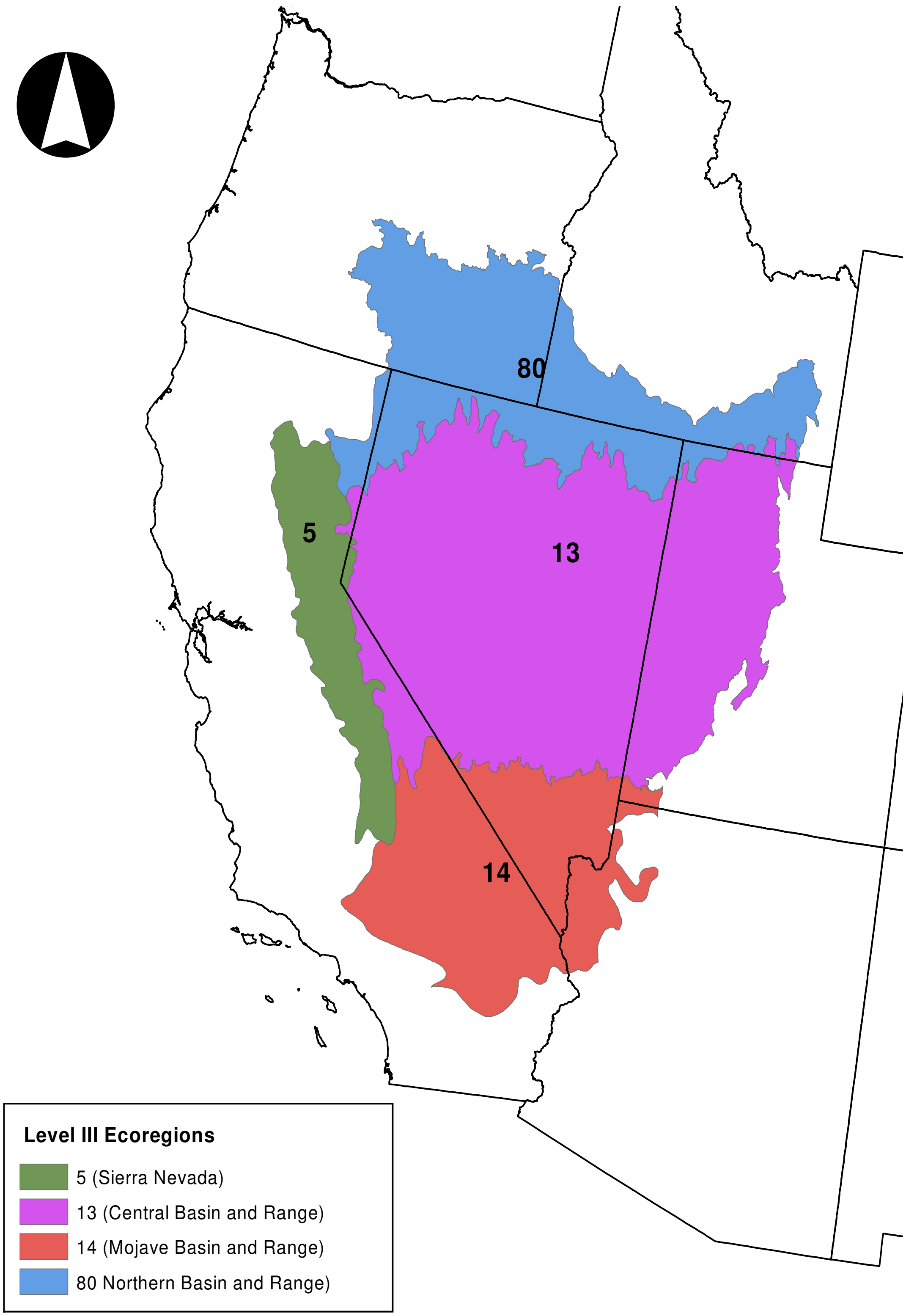

Figure 2. Level III Ecoregions in Nevada

Lakes and Reservoirs

EPA's 304(a) recommendations for lakes and reservoirs were developed in a similar manner to the river and stream recommendations. The resulting recommendations are summarized in Table 2.

Table 2. Reference Conditions for Level III Ecoregion Lakes and Reservoirs, mg/l (25th Percentile of Dataset)

Parameter	Ecoregion 5 (Sierra Nevada)	Ecoregion 13 (Central Basin and Range)	Ecoregion 14 (Mojave Basin and Range)	Ecoregion 80 (Northern Basin and Range)
TKN	0.24	0.34	na	0.016
NO2 + NO3	na	0.01	na	0.01
TN (calculated)	na	0.35	na	0.17
TN (reported)	0.25	0.51	na	na
TP	0.015	0.030	na	0.086
Secchi (m)	na	2.3	na	2.8
Chlorophyll-a (ug/l)	na	1.9 – 3.5	na	3.1 – 4.4

EPA Region IX RTAG Findings

Since 1998, Nevada has been participating in Region IX RTAG meetings with representatives from EPA, California, Arizona, consulting firms, research organizations, etc. While the focus of the RTAG efforts have largely been on California waters, NDEP has participated in the process in hopes of identifying an approach for improving Nevada's existing nutrient criteria. It was also thought that Nevada could potentially follow California's nutrient criteria development plan.

With the assistance of TetraTech, the Region IX RTAG has made progress toward improved nutrient standards. A comparison of the EPA 304(a) criteria with the findings of a pilot study indicated the use of the 304(a) criteria would result in numerous waters being misclassified as impaired. Overall, the RTAG concluded that nutrient concentrations (both nitrogen and phosphorus species) alone are poor predictors of the likelihood of impairment. Other factors such as substrate conditions, light, flow, turbidity, days of accrual, etc. also affect algal dynamics and potential dissolved oxygen problems (See Attachment A for further discussion on the various factors affecting algal dynamics). TetraTech and the RTAG have concluded that other secondary indicators (such as benthic algae density, dissolved oxygen) provide more direct evidence of nutrient impairment status. Therefore, the RTAG decided to pursue an alternative approach to EPA's 304(a) criteria. However it is believed that additional data are needed throughout California to better understand the linkages between nutrients and these secondary indicators.

The proposed California approach calls for the generation of site-specific nutrient numeric endpoints as part of TMDL development activities throughout the state. Overtime, a robust database will accumulate with improved nutrient and secondary indicator data that the Regional Water Boards could use "*to move beyond these site-specific applications"* and set water quality standards. To assist the Regional Board in the development of nutrient numeric endpoints, TetraTech and the RTAG developed a unique approach that includes:

- ❑ A beneficial use risk classification framework
- ❑ Risk-based secondary indicators
- ❑ Modeling tools to link secondary indicators to nutrient concentrations

According to TetraTech and the RTAG (2005), "*for many of the biological indicators associated with nutrients there is not clear scientific consensus on a target threshold that results in impairment*." Three Beneficial Use Risk Categories (BURC) have been proposed to begin addressing this problem:

> BURC I – waterbodies are not expected to exhibit nutrient impairment (presumptively unimpaired)
> BURC II – waterbodies may require additional information and analysis to determine status (potentially impaired)
> BURC III – waterbodies have a high likelihood of exhibiting nutrient impairment (presumptively impaired)

In support of this classification system, the RTAG agreed upon some secondary indicator values defining the boundaries between each of these BURCs (See Table 3). For translating the secondary indicators into numeric nutrient criteria, TetraTech provided some simplified modeling tools. However, the RTAG recognizes that more detailed modeling tools may be needed for some TMDLs. The RTAG emphasizes that these tools are only a single line of evidence and need to be used as part of an overall approach with multiple lines of evidence considered.

Table 3. Nutrient Numeric Endpoints for Secondary Indicators – EPA Region IX RTAG

Response Variable	Risk Category	Beneficial Use						
		COLD	**WARM**	**REC-1**	**REC-2**	**MUN**	**SPWN**	**MIGR**
Benthic Algal Biomass (chl-a, mg/m2) – Maximum	I	<100	<150	C	C	<100	<100	B
	II	100 - 150	150 - 200			100 - 150	100 - 150	
	III	>150	>200			>150	>150	
Planktonic Algal Biomass in Lakes and Reservoirs (chl-a, ug/l) – summer mean	I	<5	<10	<10	<10	<5	A	B
	II	5 – 10	10 - 25	10 - 20	10 -25	5 - 10		
	III	10	25	20	25	10		
Clarity (Secchi depth, m) – summer mean	I	A	A	>2	>2	A	A	B
	II			1 - 2	1 – 2			
	III			<1	<1			
Dissolved Oxygen (mg/l) – Streams, mean of 7 daily minimums	I	>9.5	>6.0	A	A	A	>8.0	C
	II	5.0 – 9.5	4.0 – 6.0				5.0 – 8.0	
	III	<5.0	<4.0				<5.0	
pH maximum – photosynthesis driven	I	<9.0	<9.0	A	A	A	C	C
	II	9.0 – 9.5	9.0 – 9.5					
	III	9.5	9.5					
Dissolved Organic Compounds	I	A	A	A	A	<2	A	A
	II					2 – 5		
	III					>5		

A = no direct linkage
B = more research needed to quantify linkage
C = addressed by aquatic life criteria
COLD = coldwater fishery; WARM = warmwater fishery; REC-1 = non-contact recreation; REC-2 = contact recreation; MUN = municipal supply; SPWN = fish spawning; MIGR = fish migration

As part of an initial effort to test this approach, eight pilot waterbodies through California are being evaluated following the RTAG procedures and associated modeling tools. These waterbodies either have a TMDL that is completed or underway. RTAG recommendations for continued refinement of the California approach include:

- Supply collected data from the pilot waterbodies into California State Water Boards databases
- If the Regional Water Boards approve the approach, they should consider development of draft waterbody impairment assessments based on the proposed BURC
- Develop monitoring guidance for all secondary indicator parameters (algae, dissolved oxygen, etc.) and procedures for conducting BURC impairment assessments

As future work within this framework occurs, refinements can be made with the classification system, secondary indicators and linkage analysis models. It is still uncertain how this information will be translated into numeric water quality standards.

Upon review of Tetra Tech's most recent document for the RTAG (*Technical Approach to Develop Nutrient Numeric Endpoints for California*, 2006), NDEP believes that a different approach may be appropriate for Nevada. Like California, Nevada also needs more data to better understand linkages between nutrients and secondary indicators, such as algal biomass. However, Nevada is not likely to pursue the collection of these data through its TMDL program. While there are numerous waterbodies on Nevada's Draft 2006 303(d)/305(b) Integrated Report for exceedances of total phosphorus standards, there is great uncertainty as to which waters actually have eutrophication problems and for which TMDLs may be appropriate. Nevada is opposed to developing TMDLs for listed waters unless impairment can be confirmed through additional lines of evidence, such as algal biomass or dissolved oxygen.

Nutrient Criteria Strategies by Selected States

Following is a summary some of the nutrient criteria efforts undertaken in some other states. The purpose of this discussion is to provide a variety of examples to draw from in designing Nevada's approach.

Arizona

While Arizona has participated in the EPA Region IX RTAG, they have decided to develop their own approach for nutrient criteria. Arizona's first priority has been the development of lakes/reservoir criteria. The proposed approach being pursued by Arizona is to maintain narrative nutrient criteria in the regulations, while providing implementation procedures for the narrative standards.

According to the proposed regulations, a lake or reservoir is considered to be in violation of the narrative nutrient standard if the numeric target[1] for chlorophyll-a is exceeded. If chlorophyll-a concentrations are within the allowable ranges set in the endpoint matrix, ADEQ will employ a weight-of-evidence approach and consider the following factors in determining impairment status:

- Evidence of toxic algae blooms

[1] As part of a 2-year study during which over 70 lakes and reservoirs were sampled, Arizona has developed a lake classification system[1] and an associated matrix of numeric targets (chlorophyll-a, secchi depth, total nitrogen, total Kjeldahl nitrogen, total phosphorus, percent blue-green algae, and total count of blue-green algae) for the various beneficial uses.

- Fish kills
- Taste or odor problems in the water
- The concentrations of TP, TN, TKN exceed the upper value in range prescribed in the endpoint matrix
- The concentration of blue-green algae exceeds 20,000 per milliter
- The percentage of blue-green algae is greater than 50% of the total algae count

While the revised regulations are not yet approved, it is interesting to note that Arizona is proposing to remove some numeric nutrients standards for 3 lakes and replace them with the narrative nutrient standard implementation approach.

Colorado

Colorado recently completed a study examining key nutrients (phosphorus, nitrogen) and biological indicators (periphyton biomass, periphyton species composition, macroinvertebrate abundance and composition) for montane streams (Lewis and McCutchan, 2005). For streams, the biological data indicated no thresholds or trends related to nutrient levels. They found weak evidence for a community change above a threshold of approximately 0.050 mg/l, and concluded that ecological thresholds for nutrients likely exist at nutrient concentrations above those observed in this study.

Tennessee

In support of their nutrient standards development, Tennessee undertook a statewide assessment of nutrient levels, periphyton densities, and dissolved oxygen patterns in impaired and reference streams (Tennessee DEC, 2003). Like others, Tennessee concluded that nutrients are a poor indicator of eutrophication impairment.

At this time, Tennessee still has only narrative nutrient standards. However their regulations states that the interpretation of the narrative standard may be made using the document titled "Development of Regionally-based Interpretations of Tennessee's Narrative Nutrient Criterion" and/or other scientifically defensible methods. Tennessee developed the above document using a variation of the EPA 304(a) criteria approach. Data for various reference sites within the various Level IV ecoregions were evaluated and they concluded that the 90th percentile of the reference site phosphorus and nitrogen concentrations is a better threshold than the 75th percentile suggested by EPA (2000) in setting nutrient criteria. Relationships between nutrient data and biological indices were explored with some success. The available biological data supported the use of the 90th percentile threshold.

New Mexico

As discussed earlier, EPA is recommending three approaches for states to following in developing nutrient criteria. New Mexico is proposing to use of combination of Approaches 1 and 3 (NMED, 2006):

> **Approach 1** - develop nutrient criteria that fully reflect localized conditions and protect specific designated uses using EPA's Technical Guidance Manuals (EPA 2000)
>
> **Approach 3** – develop a unique, scientifically defensible method using empirical approaches, loading models, cause and effect-based studies, other analytical tools.

New Mexico will develop nutrient threshold values for different waterbody types and different classes within each type. The first step will be the compilation of existing data. Then, data gaps will be identified with additional data collected to fill these gaps. Data will include TN, TP, chlorophyll-a, total suspended solids, turbidity, DO, pH, benthic macroinvertebrates, periphyton, geology, elevation, watershed size, and stream order. Based upon these data, impairment thresholds will be determined for each waterbody class and type. However, their plan provides little detail on how these thresholds may be developed. The next step will be to test and refine the thresholds.

Once the thresholds have been thoroughly tested, numeric TN and TP criteria are to be adopted into the state water quality standards, while thresholds for other variables (DO, pH and chlorophyll-a) will be incorporated into the weight of evidence approach used in their assessment protocol for the 303(d) listing of waters. It is uncertain how the State will be able to base listing decisions upon criteria (chlorophyll-a) not in their regulations.

Utah

Utah regulations include total phosphorus indicator levels which are used to identify waters "needing further evaluation." These additional evaluations are needed before a waterbody is listed on the 303(d). Additional evaluations could include benthic macroinvertebrate data, diurnal dissolved oxygen data, habitat quality evaluations, and fisheries data.

Nevada's Nutrient Criteria Approach

As previously discussed, Nevada has established nutrient criteria for many of its waters. While these criteria have shortcomings, NDEP is still required to use these criteria as our basis for the 303(d) Listing analyses. This document attempts to address strategies for dealing with issues associated with the existing standards, along with strategies for working toward improved nutrient standards for all waters.

Existing Nutrient Criteria

An understanding of Nevada's existing nutrient criteria is a necessary first step before developing an overall strategy. Nevada's water regulations contain two types of nutrient criteria: beneficial use criteria and RMHQs (Requirements to Maintain Existing Higher Quality).

- ❑ The beneficial use criteria have generally been derived from EPA guidance as needed to protect the most restrictive use.
    - o Phosphorus – Most of the waters have TP standards ranging from 0.05 to 0.10 mg/l for the protection of aquatic life.
    - o Nitrogen – Most of the waters have Nitrate standards of 10 mg/l (as Nitrogen) for the protection of drinking water uses. Nevada regulations contain no beneficial use nitrogen limits for the control of eutrophication. The Truckee River has a nitrate standard of 2 mg/l (as N) due to toxicity concerns related to Lahontan Cutthroat Trout. No waters have Total Nitrogen beneficial use standards.
    - o Dissolved Oxygen – most waters have DO standards of 5.0 or 6.0 mg/l.
- ❑ RMHQs are part of Nevada's antidegradation policy. Under the current approach, discharge permit limitations are set based upon RMHQs if they exist for the particular water. If they do not exist, beneficial use standards are used for setting effluent limits. RMHQs are generally calculated as the 95^{th} percentile of the historic sample data. RMHQs are set for reaches where the 95^{th} percentiles are better quality than the Beneficial Use standard.

- Phosphorus – Most Phosphorus RMHQs have been set for TP. The Truckee River has both TP and OP RMHQ values.
- Nitrogen – Most of the nitrogen RMHQs have been set for TN. A few waters have nitrate RMHQs.

While several waterbody reaches have TN RMHQs and are meeting these RMHQs, one should not assume that all of these waters are free from eutrophication problems.

Proposed Approach

Nevada's proposed approach draws from several methods presented by other states and EPA. The foundation of the strategy is the well-recognized conclusion that nitrogen/phosphorus levels alone are poor indicators to nutrient problems. It is difficult to impossible to reduce our complex water systems to a simple set of numeric nutrient values. There will be considerable uncertainty with any criteria that are utilized, therefore considerable flexibility is needed in dealing with nutrient issues. Unfortunately, water quality standards have tended to focus on black-and-white demarcations between unimpaired and impaired conditions, with little room for flexibility.

EPA recognizes the need to move beyond just water chemistry for nutrient standards. In a May 26, 2007 memorandum, Benjamin Grumbles, EPA Assistant Administrator, encourages the adoption of standards for both causal (both nitrogen and phosphorus) and response (chlorophyll-a and transparency) variables.

Whatever Nevada chooses to do, it needs to:
- ❑ Be scientifically defensible and protect the designated uses
- ❑ Consider the potential effects of the proposed criteria on downstream water quality and uses

Short-Term Strategy

Until more progress is made in developing appropriate nutrient criteria, the following short-term strategies are recommended, separated into 2 divisions: 1) addressing waters with existing nutrient criteria; and 2) addressing new waters to be added to the regulations. A slightly different approach is suggested for these 2 water classifications. There are a number of waters in the state that are not specifically mentioned in the regulations, yet warrant improved protection. Part of the NDEP Long Range Plan is to include more of these waterbodies in the water quality regulations.

1. Waters with existing nutrient criteria

    a. Since phosphorus criteria are in the regulations, NDEP is required to use these values in determining use status for the 303(d) Impaired Waters List (Category 5 of the Integrated Report). Currently, the ability to revise these values is limited.
    b. The existing phosphorus criteria will be used as indicators of "potential" use support or impairment. Algae, DO data, etc. can be used to assess the actual support status.
    c. For waters on the 303(d) List for phosphorus, followup activities should take place (as resources allow) to determine whether or not nutrient-related problems exist and what may be appropriate next steps (such as TMDLs, etc.) – See *Nevada's Nutrient Assessment Protocols for Wadeable Streams* (NDEP, 2007) for discussions on determining use support status.
    d. Additional protection can be achieved with the addition of RMHQs (total nitrogen, dissolved inorganic nitrogen, total phosphorus, orthophosphates) depending upon the availability of sufficient data.

e. These waters all have dissolved oxygen standards in the regulations. It is believed that DO may be a better indicator of nutrient impairment status than N and P. However, low flows can also contribute to low DO conditions.
f. For waters like the Truckee River where considerable effort has gone into data collection and modeling, the modeling tools should be evaluated for potential use toward refined nutrient criteria.

2. New waters added to regulations

   a. P and N criteria should not be added to the regulations, unless available data suggests otherwise. Instead, preliminary P and N indicators should be established for assessment purposes only. When indicators are exceeded, followup assessment activities should take place (as resources allow). It is anticipated that the P and N indicators will be refined and tested as more data are collected. See **Section: Long-Term Strategy** for more discussion on indicators.
   b. Waterbodies should be placed on the 303(d) List (Category 5 of the Integrated Report) for nutrients if followup assessments indicate impairment – See *Nevada's Nutrient Assessment Protocols for Wadeable Streams* (NDEP, 2007) for discussions on determining use support status.
   c. Assign dissolved oxygen standards in the regulations. It is believed that DO may be a better indicator of nutrient impairment status than N and P. However, low flows can also contribute to low DO conditions.
   d. Additional protection can be achieved with the addition of RMHQs (total nitrogen, dissolved inorganic nitrogen, total phosphorus, orthophosphates) depending upon the availability of sufficient data.

Long-Term Strategy

As stated earlier, many states and others have concluded that nutrient levels are not a good indicator of eutrophication impairment. Attempts in other states to develop relationships between N and P levels and stream impairment status have met with minimal success. With that in mind, it seems that future nutrient criteria may need to incorporate considerable flexibility recognizing all the other factors that play a role in eutrophication (shading, flow, substrate, etc.). Unfortunately, this can be challenging as water quality standards have historically focused on black-and-white N and P demarcations between "use support" and "use impairment". Additionally, consideration will need to be given to potential tiered aquatic life uses which recognizes the gradient of levels of aquatic use support.

Four basic steps have been identified for the long-term strategy:

1. Initiate Sampling Program for Nutrients, Algae Characterization, Physical Conditions, Macroinvertebrates
2. Evaluate data to identify possible N and P threshold indicators (and other indicators) by Ecoregion Level IV areas (Figure 2) or other appropriate geographic delineation
3. Test indicators, and refine as appropriate
4. After considerable testing, consider incorporating indicators in the regulations as criteria

1. Initiate sampling program for nutrients, algae characterization, physical conditions, macroinvertebrates

At this time, there are little algal data for Nevada waters. A key part of Nevada's strategy is to begin collecting data on algae, nutrients, etc. as resources allow; and to promote opportunities with others such as EPA, DRI, USGS, BLM, USFS, etc. to assist in the development of algae, nutrient, physical condition information, etc. A long term goal should be to collect data for a range of waterbody types, with varying use support/impairment conditions (reference sites to 303(d) listed waters), within each Ecoregion Level IV area (Figure 2) within Nevada. It may be appropriate to target some of the same sites that have been monitored or will be monitored under EMAP and REMAP (Regional Environmental Monitoring and Assessment Program)[2] along with other sites where macroinvertebrate data are being developed. Ultimately, appropriate nutrient criteria may need to be linked to macroinvertebrate indices.

Monitoring of rivers and streams is recommended to include the following:

- ❑ N and P species
- ❑ dissolved organic carbon
- ❑ periphyton chlorophyll-a and AFDM (ash-free dry mass)
- ❑ periphyton species composition
- ❑ algal percent cover of substrate, N/P/C stoichiometry of algae
- ❑ diel DO monitoring
- ❑ diel temperature monitoring
- ❑ diel pH monitoring
- ❑ physical conditions (shading, substrate, flow, channel characteristics (slope, width, depth, etc.))
- ❑ macroinvertebrates

Algal conditions for a given waterbody can have great temporal and spatial variability. For a given water, it will be desirable to monitor at a number of locations several times during the growing season (or longer), possibly for multiple years. **NOTE: The current State Health Laboratory detection limit for nitrate (0.10 mg/) is not low enough to perform the level of investigation needed for the long-term strategy.**

For lakes and reservoirs, the following monitoring is recommended:

- ❑ N and P species
- ❑ pH
- ❑ dissolved organic carbon
- ❑ phytoplankton chlorophyll-a and species composition
- ❑ secchi depth
- ❑ dissolved oxygen profiles
- ❑ temperature profiles
- ❑ physical conditions (volume, depth, surface area, inflow/outflow)

Like in streams, algal levels in lakes/reservoirs can be variable. Monitoring may need to occur at several locations on a lake/reservoir, several times during the growing season (or longer), and possibly over multiple years.

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[2] Beginning in 2006, NDEP embarked on a 3-year project to establish a classification system and evaluate, through monitoring and data analysis, the conditions of the physical habitat, water chemistry, and biological conditions of wadeable 1st, 2nd and 3rd order perennial surface waters throughout the state. Extensive sampling/characterizations will occur including macroinvertebrates, periphyton, fish, water chemistry, chlorophyll-a, sediment chemistry, fish contaminants, and physical habitat measurements.

Region IX RTAG is planning on developing guidelines for algal monitoring for use in evaluating use support status and establishing nutrient criteria. These guidelines may prove useful for Nevada's nutrient criteria effort. Nevertheless there are a variety of algal monitoring methods that can be implemented, ranging from rapid methods to more rigorous quantitative methods. Barbour et al. (1999) provides protocols for periphyton sampling in wadeable streams. While two sampling approaches are presented (multihabitat and single habitat sampling), the single habitat sampling approach is recommended when periphyton biomass is to be assessed. The recommended substrate/habitat combination is cobble obtained from riffles and runs. Examples of other approaches are provided by Biggs and Kilroy (1994) and New Mexico Environment Department (2004). NDEP may wish to test out the various protocols available before deciding on one consistent approach, or develop its own protocols as needed.

2. Evaluate data to identify possible N, P and algal threshold indicators (and other thresholds) by Ecoregion Level IV areas or other appropriate geographic delineation.

Throughout the data collection process, analyses could be undertaken on an ongoing basis. The goal of the analyses would be to identify possible N, P, benthic algae levels, phytoplankton levels and other thresholds that may be useful indicators of nutrient impairment status. Ultimately, it may be desirable to establish a variety of indicators for different geographic areas (such as Ecoregion Level IV, See Figure 3), elevation, waterbody type, flow, etc. Comparisons of benthic macroinvertebrate populations with N, P and algae levels may yield useful impairment thresholds. The actual analysis approach to be used is undetermined at this time, and will have to be tested over time as the database size increases.

3. Test indicators, and refine as appropriate

As indicators are developed, NDEP will test their ability to serve as surrogates for nutrient impairment. One approach for testing indicators could be to undertake assessments similar to those presented in *Nevada's Nutrient Assessment Protocols for Wadeable Streams* (NDEP, 2007). This document describes the proposed approach for making use support determinations as related to nutrients.

It is recommended that Steps 1 through 3 be undertaken with an adaptive management approach, making adjustments in the data collection, analyses, indicator testing methods as appropriate in response to a growing dataset and knowledge of nutrient dynamics in Nevada's waters.

4. After considerable testing, consider incorporating indicators in the regulations as criteria

After thoroughly using/testing the protocols and the associated indicators, it may be possible to begin incorporating these indicators into the regulations as criteria. However, it is expected that such a step may be years in the future. Current information suggests that a multiple line-of-evidence approach is more appropriate for determining nutrient impairment status, rather than relying solely on N and P criteria. With that in mind, incorporation of multiple line-of-evidence (nutrient concentrations, algae levels, DO levels) criteria into the regulations may be desireable. It may also be appropriate to assign growing season criteria, and avoid annual average criteria for streams.

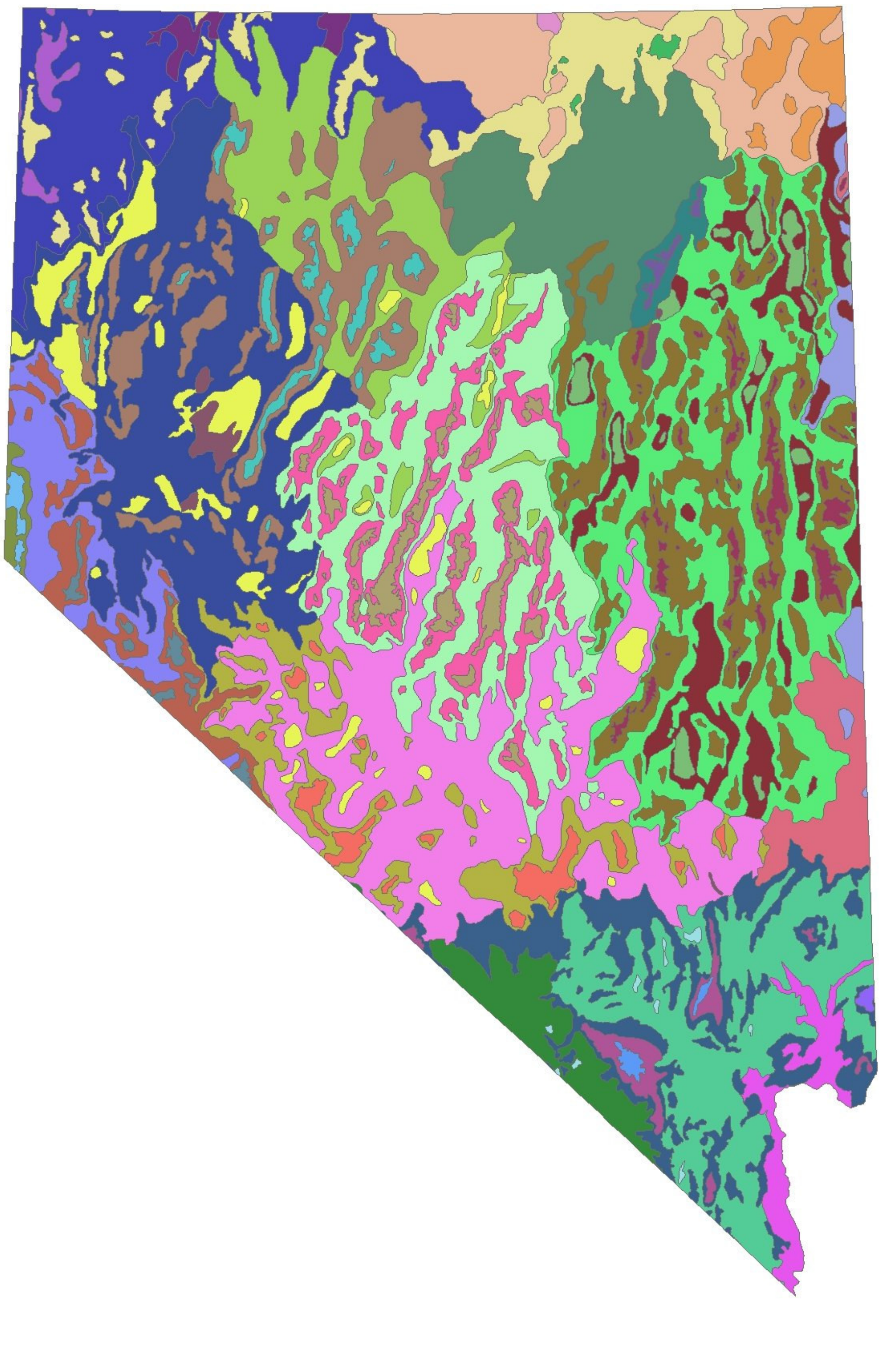

Figure 3. Nevada Ecoregions Level IV

Future Work

It is expected that this Nutrient Strategy document will be revised with time as NDEP increases its understanding of nutrients throughout the state. Some of the questions that need to be addressed include:

- What are the appropriate sampling and analytical protocols for benthic algae taking into account:
    - temporal and spatial variability
    - varying substrate conditions (sand vs. cobble)

- What level (density and overall extent) of algal biomass constitutes impairment given that streams have a gradient of Aquatic Life Uses (from excellent to poor) that need to be recognized?

- At what point does algal biomass begin to negatively impact dissolved oxygen levels? While it is recognized that algae/DO relationship are highly variable due to affects by other factors such as flow conditions, channel characteristics, is it possible to identify algae/DO thresholds for different stream types?

- What is the extent and impact of blue-green algae in Nevada waters? How should the occurrence of blue-green algae be accounted for in setting nitrogen water quality standards?

- What affect do diel fluctuations in nutrients have upon daytime nutrient sampling results? Does this phenomenon need to be accounted for when setting nutrient criteria?

- How do physical conditions (including flow) affect nutrient/algal relationships? How should these conditions be accounted for in the setting of nutrient criteria?
    - While streams with better physical conditions (good shading, etc.) can handle more nutrients than lesser streams, the better streams probably should not have higher (less restrictive) N and P standards than the poorer streams.
    - Nevada regulations state only that standards do not apply during “extreme” events, however “extreme” has not been defined. The 7Q10 low flow statistic has been used upon occasion as a threshold for determining when flows are “extremely” low. While a useful approach, 7Q10 statistics can only be calculated for streams with gaging stations which exist for only a small subset of the state’s waters.

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